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Glossary of Terms. A Report of the NATO/CCMS Pilot Study on Air Pollution Assessment Methodology and Modeling

NATO Committee on the Challenges of Modern Society, Brussels (Belgium)

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This document establishes a comprehensive glossary of terms used in air pollution assessment methodology and modeling.

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Glossary of Terms

A Report of the NATO/CCMS Pilot Study

on Air Pollution Assessment Methodology and Modeling

N. 89

COMMITTEE ON THE CHALLENGES OF MODERN SOCIETY

NORTH ATLANTIC TREATY ORGANIZATION

October 1978

Preface

The North Atlantic Treaty Organization (NATO) established the "Committee on the Challenges of Modern Society" (CCMS) at the November 1969 meeting of the North Atlantic Council.

The CCMS was charged with developing meaningful environmental and social programs that complement other international programs, and with showing leadership, first, in solution of existing problems and, second, in development of long-range goals for environmental protection in the NATO sphere of influence and in other countries as well. A first Pilot Study on Air Pollution was initiated by the CCMS at its inaugural meeting in December 1969. The United States (Environmental Protection Agency) has been the pilot nation with the Federal Republic of Germany (Federal Ministry of the Interior) and Turkey (Scientific and Technical Research Council) as copilot-nations.

The Pilot Study on Air Pollution was an action program designed to demonstrate and encourage the utilization of existing knowledge for the development of air quality management programs. It entailed the demonstration of a system approach to air quality management. Case studies have been carried out in Ankara, Turkey; Frankfurt, Federal Republic of Germany; St. Louis, U. S.; Oslo, Norway; South Holland Region, The Netherlands (NATO/CCMS Report No. 6, Appendices A - E).

The results of the pilot study are documented in NATO/CCMS Report No. 6 (Revised) "Guidelines to Assessment of Air Quality" of October 1972 and in NATO/CCMS Report No. 33 (Final Report) containing 15 recommendations as well as in several other documents, listed as Annex II to this document.

Starting from three of the above recommendations (VI, VII and XIV) the Federal Republic of Germany proposed to initiate a new Pilot Study on Air Pollution Assessment Methodology and Modeling at the CCMS Plenary Session on October 22 and 23, 1974.

These NATO/CCMS Recommendations are:

RECOMMENDATION VI

Member nations will co-operate to develop standardized methods for emissions data storage and retrieval to support requirements in the conduct of national air quality management programs. The US National Emission Data System (NEDS) might serve as a model for a common international system.

RECOMMENDATION VII

Member nations will co-operate to develop standardized techniques for projecting emissions and predicting future ambient air quality.

RECOMMENDATION XIV

Member nations agree the CCMS modeling activity has shown that there is a widespread need for further international co-operation to accomplish the following tasks:

Bring together model developers and air quality managers for exchange of ideas, discussion of users' needs and demonstration of modeling techniques.

Standardize modeling techniques for specific air quality management applications and consider how computerized models might be made available for all users.

Continue to review on-going air quality assessment studies.

In spring 1975 the North Atlantic Council approved the German proposal. The pilot study work started with the Federal Republic of Germany (Federal Ministry of the Interior) as pilot nation and the United States of America (Environmental Protection Agency) and Belgium (Service du Premier Ministre) as co-pilot nations:
A Working Group and two Panels were established with the following functions:

Assessment Methodology Panel

- Pursue and carry out Recommendations VI and VII
- Continue to review present and future assessment studies with respect to the application of assessment methodology.

Modeling Panel

- Develop standardized models for various air quality management applications.
- Develop programs to improve modeler/user communications in conjunction with the Assessment Methodology Panel and the Working Group.
- Continue as an information forum on new modeling concepts and techniques, organizing once a year international technical meetings on air pollution modeling and its application.

In addition the Working Group established an Ad-Hoc Group on Air Quality Management Systems to revise and update the NATO/CCMS Report No. 6 (Revised) 1972 by preparing a new document on "Guidelines to Air Quality Management Systems".

Another Ad-Hoc Group was set up for compiling a Glossary of Terms frequently used in assessment methodology, modeling and air quality management systems.

As an outcome of this Pilot Study on Air Pollution Assessment Methodology and Modeling the following NATO/CCMS documents are published (see also Annex III):

Air Quality Management System

- Guidelines to Air Quality Management System.

Assessment Methodology

- Air Pollution Emissions Inventory Systems
- Air Pollution Emissions Projecting

Air Pollution Modeling

- Introduction to Air Quality Modeling
- Uses and Needs for Air Quality Modeling
- Bibliography on Grey Literature on Air Quality Modeling, Part I (Applied Models)
- Bibliography on Grey Literature on Air Quality Modeling, Part II (New Modeling Techniques)
- Practical Demonstration of Multiple Source Urban Air Quality Modeling (Gaussian Plume)
- Fundamentals for the Applications of a Gaussian Plume Model

Other Publications

- Glossary of Terms
- Proceedings of the 6th International Technical Meeting on Air Pollution Modeling and its Application (24 - 26 September 1975, Frankfurt/Main, Germany)
- Proceedings of the 7th International Technical Meeting on Air Pollution Modeling and its Application (7 - 10 September 1976, Airlie House, USA)
- Proceedings of the 8th International Technical Meeting on Air Pollution Modeling and its Application (20 - 23 September 1977, Louvain-la-Neuve, Belgium).

The chairman of the Working Group wishes to acknowledge the scientists participating from pilot, copilot, and observer countries, and the many other persons, who assisted in the preparation of this document.

The ad-hoc group, which performed diligently throughout the course of this effort, receives the highest praise. The ad-hoc group members were:

Federal Republic of Germany - Pilot Country

H. Meinl C. Morawa

The Netherlands-Observer

F. Nieuwstadt

The names and addresses of all panel members are listed in Annex I.

Full recognition is given to each panel member for carrying out and coordinating review and other activities related to the development of this document in his respective country and to Ms. C. Morawa of the Federal Environmental Office, Germany for her effort in coordinating and organising and for editorial work.

For the Working Group,
Erich Weber, Chairman.

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Introduction

During their work on the technical documents the panel members realized that some terms used in the various national papers differed considerably; therefore both panels decided to establish a comprehensive glossary of terms used in air pollution assessment methodology and modeling; the terms have been defined by the aid of the following already existing publications:

Compilation of Air Pollution Emission Factors U.S. Environmental Protection Agency, 1972

General Aspects of Air Quality/Terminology International Organization for Standardization ISO/DP 4225

Glossary, contained in:
Environmental Monitoring, Vol IV, Analytical Studies for the U.S. Environmental Protection Agency
by: The National Academy of Sciences, 1977

Huschke, R. E. (Editor)
Glossary of Meteorology, American Meteorological Society

Huschke, R. E. (Editor)
Glossary of Terms Frequently Used in Air Pollution
American Meteorological Society, 1972

International Meteorological Vocabulary,
World Meteorological Organization - No. 182 TP 91

Pasquill, F.
Atmospheric Diffusion, 2nd Edition, John Wiley u. Sons

Seinfeld, J. H.
Air Pollution, Mc Graw-Hill Book company

Slade, D. H. (Editor)
Meteorology and Atomic Energy, U.S. Atomic Energy Commission

Stern, A. C.
Air Pollution Vol. I, II, III, 2nd Edition, Academic Press

Studdard, G. J.
Common Environmental Terms - A Glossary
U.S. Environmental Protection Agency, 1974

Suess, M. J., S. R. Craxford (Editors)
Manual on Urban Air Quality Management
WHO Regional Publications European Series No. 1, 1976

Absorption

- The uptake of radiant energy by a substance. During this process the radiant energy is irreversibly transformed into some other form of energy e. g. thermal, mechanical or electrical energy.

- The uptake through chemical combination of one substance by another.

Accumulation

The increase of concentration levels in a region, due to the combined effect of emissions and meteorological conditions for which the dispersion is poor, e. g. during a stagnation period.

Adiabatic process

A thermodynamic process within a system during which no transfer of heat occurs across the boundaries of the system. In the atmosphere an adiabatic upward movement of an air parcel results in cooling through expansion, an adiabatic downward movement results in warming through compression. This process explains the adiabatic lapse rate in a neutral atmosphere.

Adiabatic lapse rate

The rate of decrease of temperature with height in the atmosphere when adiabatic upward or downward motions of the air are neither enhanced nor suppressed.
For dry conditions this lapse rate is equal to g/c_p where g is the acceleration of gravity and c_p the specific heat of dry air at constant pressure. The numerical value is equal to -0.98 °C/100 m. When condensation occurs the moist adiabatic lapse rate is less than this value because of the release of latent heat. The exact value of the moist adiabatic lapse rate is dependent on the temperature. An approximate value for a temperature of 15 °C is equal to -0.48 °C/100 m.

Adsorption

The adhesion of a thin film of gas or liquid to the surface of a solid or of another liquid. No chemical reactions are involved.

Advection

The process of transport of a property (e. g. pollution or momentum) solely by the velocity field in a fluid. For a turbulent flow advection refers only to the transport by the mean motion, where mean is defined as the time average. In meteorology advection refers only to the horizontal or isobaric component of the atmospheric motion.

Aerosol

A colloidal suspension of solid and liquid particles of microscopic or submicroscopic scale in the air (e. g. fine dust or salt particles).

Air Contaminant

See: Air pollutant

Air pollutant

A substance in ambient atmosphere, resulting from the activity of man or from natural processes, causing adverse effects to man and the environment (also called "air contaminant").

Air pollution

Presence of air pollutants.

Air pollution emissions inventory

An information collection and processing system containing data on emissions of, and sources of, air pollution from both man-made and natural causes.

Air pollution episode

The occurrence of exceptionally high concentration levels of air pollution during a period usually of the order of a few days. An air pollution episode may be caused for instance by accumulation.

Air pollution index

- In air pollution modeling, a measure of the dispersion conditions in the atmosphere based on a function of meteorological and air pollution parameters.
- A scheme that transforms the values of individual air pollution-related parameters (e. g. concentrations of several pollutants or visibility) into a single number, or set of numbers.

Air quality assessment

Collection, handling, evaluation, analysis and presentation of data necessary to understand the air pollution problem of a certain area and its causes. These data normally refer to geography, topography, land use, sources and emissions, ambient air quality, meteorology, climatology, atmospheric chemistry etc.

Air quality impact statement

A document, intended for decision making, in which the impact of proposed major activities on air quality in the near and the more distant environment is described.

Air quality management system

A system comprising coordinated measures necessary to reach and maintain an acceptable level of ambient air quality, consisting of:

- the assessment of present air quality, emissions and related factors,
- the comparison of projected emissions and ambient air quality with standards, criteria and guidelines,
- the development, implementation, and revision of abatement strategy plans, including economic aspects and interactions with other environmental media.

Air quality simulation model

A model usually in the form of a set of mathematical equations, which relates the air quality in an area to emissions.

Aliasing

See also: Fourier analysis

An error in the Fourier analysis of a time series of data where the data are given at discrete intervals. Variations associated with time scales smaller than the interval length effectively appear at lower frequencies than the so-called folding or Nyquist frequency, which is the highest frequency that can be resolved by the discrete interval length.

Ambient air quality

The quality of the ambient air near ground level, expressed as concentrations or deposition rates of air pollutants.

Ambient air quality criteria

Quantitative relationship between a pollutant's dose, concentration, deposition rate or any other air quality-related factors, and the related direct and/or indirect effects on receptors, e. g. humans, animals, plants, or materials.
Air quality criteria serve as the scientific basis for formulating ambient air quality standards or objectives.

Ambient air quality objective

Specification for the level of ambient air quality which should not be exceeded during a specified time and in a specified geographical area.
Ambient air quality objectives are not legally binding.

Ambient air quality standard

Legally binding air quality objective.

Anemometer

See also: Wind vane

An instrument for measuring the wind speed. The most common types being the cup anemometer and the propeller anemometer.

Area source

See: Source

Arithmetic mean

The arithmetic mean value $\bar{x}$ is defined:

- with respect to a sample of N discrete values x_i as

$$\bar{x} = \frac{1}{N} \sum_{i=1}^{N} x_i$$

- with respect to a continuously varying variable of space and/or time as

$$\text{time average:} \quad \bar{x} = \frac{1}{T} \int_0^T x(t)\, dt$$

$$\text{time average:} \quad \bar{x} = \frac{1}{L} \int_0^L x(s)\, ds$$

In turbulence time averages are generally used to describe the mean aspect of the turbulent field. When the averaging time encompasses all fluctuation scales, the time average can be shown to be equal to the ensemble average. This is known as the ergodic theorem.

Atmospheric diffusion

See: Diffusion

Atmospheric reactions

See also: Transformation processes

Chemical processes in the atmosphere resulting in the transformation of the participating species.

Atmospheric scavenging

See: Scavenging

Atmospheric stability

See: Unstable, Stable

Atmospheric turbulence

See: Turbulence

Austausch coefficient

See: Exchange coefficient

Auto correlation

The linear correlation between the members of an ordered series of values (e. g. a time series of observations x(t)) displaced by a certain interval τ : $\overline{x(t)\ x(t+\tau)}$.

Average

See: Arithmetic mean, Ensemble average, Geometric mean, Harmonic mean.

Averaging time

See also: Sampling time
Considering a continuously varying function of time it is the time period over which the function is given as an average.

Background level

- With respect to air pollution in general, the amount of pollutant present in the ambient air due to natural sources.
- With respect to air pollution modeling, the concentration level of a pollutant, which must be added to the concentration level of the modeled sources in order to obtain the total concentration level.

Backing wind

See also: Veering wind
Counter-clockwise rotation of the wind direction.

Baroclinity

See also: Barotropy
State of the atmosphere opposite to barotropy: density is no unique function of pressure. The surfaces of constant density (isopycnic) do not coincide with surfaces of constant pressure (isobaric). The main effect of baroclinity is that vorticity can be generated in the atmosphere.

Barotropy

State of the atmosphere in which the pressure is a unique function of the density. The surfaces of constant density (isopycnic) coincide with the surfaces of constant pressure (isobaric).

Best available control technology

Most efficient technology for reducing emissions. To be "available", it is sufficient, that a technology has proven its efficiency on a pilot scale only.

Best practicable control technology

Most effective technology for reducing emissions, taking into account factors such as ambient air quality, economic aspects or installation problems.

Bias

The systematic error in the statistical estimation of a parameter.

Bifurcation

A phenomenon where a stack plume divides, sometimes visibly, into separate plumes.

Boundary condition

A set of mathematical conditions which must be satisfied by the solution of a differential equation on the boundaries of the region in which the solution is sought.

Boundary layer

See also: Planetary boundary layer, Ekman layer
The layer of fluid in the immediate vicinity of a bounding surface, influenced by the presence of this surface. (e. g. the lower part of the atmosphere mostly known as the atmospheric boundary layer or the planetary boundary layer)

Boundary layer model

A mathematical model, mostly in the form of a set of partial differential equations, which describes the structure of the boundary layer as a function of time and space.

Boussinesq approximation

See also: Stratified fluid, Buoyancy
The assumption that a fluid, in which density variations are caused by temperature variations, can be considered as incompressible. The density variations are only taken into account when producing buoyancy forces.

Box model

A simulation model of atmospheric dispersion for which it is assumed that the concentration is uniformly distributed over a specified volume or a box. The height of the box is determined by the mixing height. The horizontal dimensions are determined by the size of the area in which the emissions take place. Across the sides of the box transport of air pollution takes place, determined by the ventilation factor F. For steady conditions the concentration c in the box becomes: $c = Q/F$ where Q is the total emission strength.

Brownian motion

The incessant and random movements of particles less that 1 μm in diameter in a fluid, caused by collision of the particles with surrounding molecules.

Building effects on dispersion

The influence by the flow patterns and turbulence around buildings on the dispersion of emissions from or in the neighbourhood of these buildings. For instance, pollution can get trapped inside the flow separation region behind a building.

Buoyancy

An upward force upon a parcel of fluid in a gravitational field due to a density difference between the parcel and the surrounding fluid.

Calibration

See also: Model calibration
The determination in terms of defined units of the indications of an instrument.

Calm

Literally the absence of apparent motion of the air. In meteorology usually applied to wind speeds less than two knots. In the meteorological data used in air pollution modeling, the periods of calm are frequently determined by the threshold value of the anemometer.

Cascade process

See also: Eddy, turbulent
The basic process in turbulence by which turbulent energy generated on the largest space scale is transported successively across various space scales by the mechanism of vorticity stretching and eventually is dissipated at the smallest scales by viscous forces.

Cause analysis

An analysis by which a causal relation is obtained between found concentration levels and emission sources.

Climatological frequency distribution

A frequency distribution of climatological parameters such as wind direction sectors, wind speed classes and diffusion categories, which is used in air quality simulation models for long term average concentrations.

Closure problem

In the Eulerian description for mean turbulent quantities more unknown terms are present than the number of equations. These additional terms originate from cross correlations between turbulent quantities (e. g. Reynolds stresses). The term "closure problem" indicates that these extra terms must be expressed as a function of the other terms in the equation in order to make a solution of the equation possible.

Coagulation

- The change of a liquid into a thick and solid state.
- Combination of small particles into fewer larger particles.

Coalescence

The merging of two droplets to form a larger droplet.

Compressible fluid

See also: Incompressible fluid
A fluid for which the density is dependent on the pressure and the temperature.

Concentration

See also: ppm, ppb
The amount of a substance, expressed as mass or volume, in a unit volume of air.

Confidence interval

The range of values which is believed, with a preassigned probability called the confidence level, to include the particular value of some parameter being estimated.

Confidence level

See: Confidence interval

Coning

A type of dispersion of a stack plume under nearly neutral atmospheric conditions, with average to high wind speeds. The horizontal and vertical dispersions of the plume are comparable.

Constant-stress layer

See: Surface layer

Continuity equation

The equation in fluid dynamics which expresses the conservation of mass.

Continuous source

See: Source

Controlled emission factor

See: Emission factor

Convection

See also: Free convection, Forced convection, Local free convection
In meteorology the vertical transport and mixing of atmospheric properties.

Convective turbulence

See: Thermal turbulence

Convergence

The gain per unit of time of a property in a volume due to the transport of this property by fluid motions through the surface into the volume. The loss of a property is called divergence.

Coriolis acceleration

The apparent acceleration of a body in a relative coordinate system, which rotates with respect to an inertial coordinate system. The Coriolis acceleration a is given by the equation $\underset{\sim}{a} = 2\underset{\sim}{\Omega} \times \underset{\sim}{v}$, where $\underset{\sim}{\Omega}$ is the angular velocity vector of the relative coordinate system and $\underset{\sim}{v}$ is the velocity vector of the body with respect to the relative coordinate system.

Coriolis parameter

The parameter given by the equation $f = 2\Omega \sin \phi$, where Ω is the angular velocity of the earth and ϕ is the latitude.

Correlation coefficient

In statistics, with respect to linear correlation between two variables, it indicates the dependence between the two variables. Complete dependence is given by a correlation coefficient of one and no dependence is given by a correlation coefficient of zero. The value of the correlation coefficient follows from the covariance divided by the product of the standard deviations of both variables.

Correlation function

In turbulence the average relation between two quantities as a function of time and/or space. For instance, with respect to the velocity components u_i and u_j the general correlation function is given by the equation $R(\underset{\sim}{x},t,\underset{\sim}{r},\tau) = u_i(\underset{\sim}{x},t)\ u_j(\underset{\sim}{x}+\underset{\sim}{r},t+\tau)$ where the average is defined as an ensemble average.
The correlation function can be expressed both in a Eulerian frame of reference and a Lagrangian frame of reference.

Cost-benefit analysis

An evaluation of the costs and the benefits of a proposed action, serving as a tool in decision making.

Covariance

Given two random variables x and y and their joint probability density function p(x,y), the covariance is defined as

$$r_{xy} = \iint (x-\xi)(y-\eta)\ p\ (x,y)\ dx\ dy$$

where ξ is the expectation of x and η is the expectation of y. The covariance is a measure for the dependence of the variation in the variables x and y.

Criteria pollutants

Pollutants for which ambient air quality standards have been designated, e. g. total suspended particulates, sulfur dioxide, carbon monoxide, nitrogen oxides, photochemical oxidants and gaseous hydrocarbons. The term "Criteria pollutant" is not used in all countries.

Cross wind

A direction perpendicular to the wind vector. Usually applied to the horizontal direction.

Cumulative frequency function

See: Distribution function

Data auditing

The process of examining data after they have been stored or archived.

Data bank

A collection of data files.

Data file

A collection of data sets.

Data processing

The systematic conversion of data (manual or automated) from one state or condition to another.

Data retrieval

The process of recovering data previously stored (see data storage).

Data set

A collection of individual data items.

Data storage

The process of placing data either manually or automatically into an organized file or any other repository from which the data can be retrieved on demand.

Data summary

The process of preparing a brief and comprehensive representation of data.

Decay

In air pollution modeling, usually applied to the decrease of an air pollutant concentration with time due to chemical and physical processes involving this pollutant.

Degree day

The difference between the mean temperature of a certain day and a reference temperature, expressed in degrees.

Dependent variable

See also: Independent variable, Parameter
Any quantity which is a function of other variables which therefore determine its value.

Deposition

The adsorption or absorption of an air pollutant at a ground, vegetation or water surface.
Deposition causes a flux of the pollutant towards the surface.

Deposition velocity

See also: Deposition
The ratio of the flux of a pollutant due to deposition and its concentration at a certain height. Apart from a function of height the deposition velocity is a function of the turbulence intensity, the molecular diffusion coefficient of the air pollutant and of the special characteristics of the surface.

Deterministic model

A model which relates emission data directly to air quality data based on the simulation of a physical process.

Differential equation

An equation expressing a relationship between functions and their derivatives. An ordinary differential equation is one with only one independent variable. In the case where derivatives with respect to more than one independent variable occur, one speaks of a partial differential equation.

Diffusion

See also: Dispersion

The movement within a fluid of a quantity from regions of high concentration of this quantity to regions of low concentration by turbulent or molecular fluid motions. In the atmosphere diffusion is primarily caused by turbulent air motions.
The concept of diffusion is also frequently denoted by the word dispersion.

Diffusion categories

These are used to characterize different turbulence intensities and therefore different dispersion conditions in the atmospheric boundary layer. The advantage of these diffusion categories over direct measures of turbulence is that the definition of these categories is based on routinely measured meteorological data. Diffusion categories are used in the Gaussian plume model to characterize the conditions for different dispersion coefficients. The Pasquill diffusion categories are a well known example.

Diffusion equation

A parabolic partial differential equation which describes the process of diffusion as a function of time and space.
For the diffusion of a property c this equation reads in a Cartesian coordinate system x,y,z

$$\frac{dc}{dt} = \frac{\partial}{\partial x} Kx \frac{\partial c}{\partial x} + \frac{\partial}{\partial y} Ky \frac{\partial c}{\partial y} + \frac{\partial}{\partial z} Kz \frac{\partial c}{\partial z}$$

Where Kx, Ky, Kz are the diffusivities or exchange coefficients, which can be a function of time and/or space.

Diffusion model

Applied to a mathematical model describing the diffusion process.

Diffusivity

See also: Diffusion equation
The coefficient of proportionality between the gradient of a property and its flux caused by molecular processes.

Dilution

The diminishing of the concentration of a pollutant by mixing it into an increasing volume.

Dilution factor

A parameter following from model calculations or measurements with the dimensions s m^{-3}. When multiplied with an emission strength, it leads to a concentration value.

Dimensional analysis

The analysis of a physical problem using only the dimensions of the dependent and independent variables and those of the basic parameters in the problem. Dimensional analysis is particularly useful for the derivation of similarity relations, where variables and parameters are grouped together in such a way that the problem can be described in terms of a few dimensionless numbers.

Dispersion

- With respect to wave phenomena: the dependence of the propagation velocity of a wave on the wave length.
- With respect to passive contaminants in fluids: the growth of the dimensions of a cloud of passive particles in the fluid, which scatter due to turbulent or molecular fluid motions. The concept of dispersion in this sense is also frequently denoted by the word diffusion.
- In air pollution meteorology the process of distributing air pollutant emissions by the combined action of advection and diffusion.

Dispersion parameters

The parameters which describe the growth of the dimensions of a Gaussian plume or a Gaussian puff as a function of travel distance or travel time. The dispersion parameters are classified according to diffusion categories, which describe the influence of different turbulence conditions in the atmospheric boundary layer on the dispersion.

Dissipation

The conversion of kinetic energy of a fluid into heat by molecular internal fluid friction.

Distribution function

Given a random variable p varying between $p_1 \leq p \leq p_2$ with the frequency function f(p) the distribution function starting from p_1 is defined as

$$F(p^*) = \int_{p_1}^{p^*} f(p)\,dp$$

giving the probability that $p_1 < p < p^*$ occurs. By definition it follows that $P(p_1) = 0$ and $P(p_2) = 1$. The distribution function can also be defined starting from p_2 giving the probability that $p^* < p < p_2$ occurs.

Diurnal variation

The variation throughout the day of a quantity in the earth's atmosphere. Usually applied to daily recurring processes.

Divergence

See: Convergence

Dosage

The time integral of the concentration c of a pollutant over a sampling time τ

$$D = \int_0^{\tau} c \, dt.$$

Dose

- In radialogy, the quantity of energy or radiation absorbed.
- In air pollution, the amount of air pollutant inhaled or absorbed.

Downdraught

The capturing of a plume by the downward air motions behind buildings or other structures. The plume reaches ground level prematurely, which results in high concentrations there.

Downwash

The downward mixing of a plume in the lee of the stack by vortex motions which are generated by the wind flow around the stack.

Down wind

The direction from a point of reference toward which the wind is blowing.

Drag coefficient

In the atmospheric boundary layer a dimensionless number equal to the ratio of the square of the friction velocity to the square of the wind speed at a given height.

Driving cycle, also called "driving mode"

A standardized simulation of a real driving situation in order to establish vehicle emission factors. The term "Driving cycle" is not used in all countries.

Driving mode

See: Driving cycle.

Dry deposition

See: Deposition

Dust

Small solid particles that are capable of being suspended in the atmosphere.

Eddy, turbulent

See also: Cascade process
In turbulent flow a portion of fluid with an organized structure of its own. An eddy can only exist for a certain time before being destroyed by breaking up into eddies of smaller size.

Eddy coefficient

See: Exchange coefficient

Eddy diffusivity

See also: Exchange coefficient
The eddy diffusivity is the coefficient which describes the diffusive property of a turbulent flow in a form analogous to the molecular diffusion coefficient. However, molecular diffusion is a property of the fluid, while turbulent diffusion is a property of the flow and can therefore be a different function of space and time for each flow.

Eddy viscosity

The same as eddy diffusivity with respect to the diffusion of momentum. Analogously to molecular viscosity it represents the internal friction in a fluid caused by turbulent motions.

Effective source height

The sum of the physical source height, which is the height of the source above ground level, and the plume rise.

Effluent

A mixture of pollutants discharged.

Eigenfunction

See: Eigenvalue

Eigenfunction expansion

The solution of an equation involving a linear operator T by assuming a solution in the form of a series involving the eigenvectors or eigenfunctions of this operator. The eigenvectors or eigenfunctions in the series are ordered according to the magnitude of the eigenvalues. In the case of an infinite number of eigenvalues the series is usually broken off at a finite number of eigenfunctions. The unknown coefficients in this series are found by substituting the series in the original equation. This results in a set of equations for the unknown coefficients which are usually simpler to solve than the original equation.

Eigenvalue

For a linear operator T on a vector space V, an eigenvalue is a scalar λ for which there is a nonzero member $\underset{\sim}{y}$ of V for which $T(\underset{\sim}{y}) = \lambda \underset{\sim}{y}$. The vector $\underset{\sim}{y}$ is the eigenvector. In the case that the vectors are functions the $\underset{\sim}{y}$ is called the eigenfunction.

Eigenvector

See: Eigenvalue

Ekman layer

See also: Planetary boundary layer

The atmospheric transition layer between the surface layer and the free atmosphere, in which the air motion is primarily determined by pressure forces, Coriolis forces and frictional forces due to the presence of the earth's surface.

Ekman spiral

In the Ekman layer a balance of pressure, Coriolis and frictional forces results in a change of wind direction and speed with height. (Originally found by Ekman in 1902 for ocean currents.)
In the northern hemisphere the wind direction change is clockwise with height. It depends primarily on the latitude and the atmospheric stability of the Ekman layer. At moderate latitudes the wind direction change between the top and bottom of the Ekman layer amounts to 20° - 30° for neutral conditions. For instable conditions it amounts to approximately 10° and for stable conditions to 40° - 60°.

Emission

The release of air pollutants into the atmosphere. Emissions include natural emissions and man-made (often called "anthropogenic") emissions.

Emission factor

An expression for the rate at which a pollutant is generated as a result of some activity, divided by the level of that activity.

It is important to distinguish between two kinds of emission factors:

1) controlled emission factor
   includes the efficiency of the applied cleaning device, thus giving the net emission for each unit of activity;
2) uncontrolled emission factor
   gives the emission for each unit of activity without any cleaning device.

Emission standard

Legally binding maximum allowed emission for a certain type of process, plant or installation, e. g. expressed in terms of concentrations or mass flow rates per pollutant, or of plume visibility.

Emissions inventory

See: Air pollution emissions inventory.

Emissions projecting

Assessment of future emissions.

Emitter

Anything or anyone causing emissions.

Energy spectrum

See: Spectrum

Ensemble average

See also: Mean value

Considering a quantity which is a random function of time and/or space the ensemble average is defined as the arithmetic average over N independent realizations of the process ($N \to \infty$). The average is calculated at the same values of the time and space coordinates with respect to each realization. The ensemble average is formally equal to the expectation. For certain conditions expressed by the ergodic theorem the ensemble average can be shown to be equal to the time or space average of the property.

Entrainment

In a turbulent flow with free boundaries it is the mixing of outside fluid across the free boundaries into the flow by turbulent processes.

Equipment standard

Legally binding specification for equipment.

Ergodic theorem

See: Mean value

Eulerian frame of reference

See also: Lagrangian frame of reference
A coordinate system in which the properties of a flow are described as a function of time and space where the coordinate system remains fixed.

Exchange coefficient

See: Exchange coefficient hypothesis

Exchange coefficient hypothesis

See also: Diffusion equation
The assumption that the turbulent flux of a property is proportional to its mean gradient. The coefficient of proportionality is called the exchange coefficient. In general this exchange coefficient can be a function of time and/or space.

Exit velocity

The velocity of the effluents at the exit of a source.

Expectation

See also: Ensemble average
Given a random variable p varying between p_1 and p_2 with a frequency function f(p) the expectation of p is defined as

$$\bar{p} = \int_{p_1}^{p_2} p\, f(p)\, dp$$

Exposure

The time integral of the concentration over a given period of time.

Fallout

The sedimentation of dust or fine particles in the atmosphere. Especially used with reference to radioactive debris.

Fanning

The fanning of a stack plume is characterized by very slow vertical diffusion during stable conditions.

Fast Fourier transform

A numerical algorithme by which the Fourier transform of a function can be obtained in a very fast and economical way.

Fickian diffusion

See also: Diffusion equation
Diffusion described by the diffusion equation in which the diffusivities or exchange coefficients can be considered as constant with respect to the time and space coordinates.

Finite difference method

A numerical method of solving differential equations by expressing the derivatives of the function as differences between values of this function at discrete points, usually called grid points.

Finite element method

A numerical solution method of e. g. a differential equation. The solution region is subdivided into subdomains or cells. A functional representation of the solution is adopted in each subdomain. The unknown parameters in each elementary solution on a subdomain can then be found, for instance, by requiring that the difference between the true solution and the finite element solution should be minimized.

Flux

The rate of transport of a quantity.

Fog

Water droplets suspended in the atmosphere near the surface, which reduce the horizontal visibility to less than 1 km.

Forced convection

See also: Convection

- The vertical transport of atmospheric properties e. g. caused by orographic lifting or horizontal wind convergence which results in an ascending air motion.
- The vertical mixing of atmospheric properties by mechanical turbulence.

Fourier analysis

The representation of physical or mathematical data by Fourier series or by a Fourier integral.

Fourier series

For a function $f(x)$, which is defined on the discrete interval $-L \leq x \leq L$, the Fourier series is defined as

$$f(x) = A_o + \sum_{n=1}^{\infty} \left(A_n \cos \frac{n\pi x}{L} + B_n \sin \frac{n\pi x}{L} \right)$$

where the Fourier coefficients are defined as

$$A_o = \frac{1}{2L} \int_{-L}^{L} f(x)\, dx$$

$$A_n = \frac{1}{L} \int_{-L}^{L} f(x) \cos \frac{n\pi x}{L}\, dx$$

$$B_n = \frac{1}{L} \int_{-L}^{L} f(x) \sin \frac{n\pi x}{L}\, dx$$

Fourier integral

For a function f(x) which is defined on the interval $< x <$ the Fourier integral is defined as

$$f(x) = \frac{1}{2\pi} \int_{-\infty}^{\infty} e^{+ikx} F(k)\, dk$$

where the Fourier transform of f(x) is defined as

$$f(k) = \int_{-\infty}^{\infty} e^{-ikx} f(x)\, dx$$

Fourier transform

See: Fourier integral

Free atmosphere

The portion of the atmosphere above the planetary boundary layer, that is no longer influenced by the presence of the earth's surface.

Free boundary

The boundary between two flow systems in a fluid.

Free convection

See also: Convection

- The vertical transport of atmospheric properties caused by the vertical air motions induced by buoyancy forces.
- The vertical mixing of atmospheric properties by thermal turbulence.

Frequency function

The function which gives the probability f(p) that the random variable p' occurs in the interval $p < p' < p + dp$. It is formally defined as the derivative of the distribution function.

Friction velocity

A velocity u_* which is defined by the equation

$$u_* = \sqrt{[\tau/p]}$$

where τ is the turbulent shear stress (Reynolds stress) and p is the density. Mostly used with reference to the shear stress near the ground, which is virtually independent of height in the surface layer.

Froude number

Non-dimensional number expressing the ratio between the inertial forces and the force of gravity for a given flow. It is given by the equation

$$Fr = \frac{V^2}{Lg}$$

where V and L are a characteristic velocity and length of the flow and g is the acceleration of gravity.

Fumigation

The rapid downward mixing of air pollution, which has accumulated in stable air at some altitude above the ground. This occurs when the stable layer between the surface and the pollutant level has been eroded by the turbulent convection following sunrise. This process leads to a suddenly increased pollutant concentration at ground level.

Galerkin method

A numerical method in which the solution of an equation is sought in the form of truncated series of orthogonal functions. By substituting this series in the original equation equations are found for the unknown coefficients in the series. These equations are usually simpler to solve than the original equation. When the orthogonal functions are the eigenfunctions of the original equation the Galerkin method is identical to the spectral method.

Gaussian distribution

See: Normal distribution

Gaussian plume model

An approximation of the dispersion of a plume from a continuous point source. The concentration distribution perpendicular to the plume axis is assumed to be Gaussian. The plume travels with a uniform wind velocity downwind from the source. Its dimensions perpendicular to the wind direction are described by dispersion parameters as a function of distance or travel time from the source. The dispersion coefficients depend on diffusion categories and sometimes also on the source height and the surface roughness. The basic assumption underlying the Gaussian plume model is that the dispersion takes place in a stationary and homogeneous atmosphere, with a sufficient wind speed ($\geq$ 1 m/s).

Gaussian puff model

See also: Puff model

An approximation of the dispersion of a puff from an instantaneous point source. The concentration distribution inside the puff is assumed to be Gaussian. The dimensions of the puff are described by dispersion parameters as a function of travel time of the puff. These dispersion coefficients depend on diffusion categories and sometimes also on the source height and the surface roughness.

Geometric mean

The geometric mean $\bar{G}$ is defined

- with respect to a sample of N discrete values x_i as

$$\ln(\bar{G}) = \frac{1}{N} \sum_{i=1}^{N} \ln(x_i)$$

- with respect to a continuously varying variable of space and/or time as

$$\text{time average:} \quad \ln(\bar{G}) = \frac{1}{T} \int_0^T \ln[x(t)]\, dt$$

$$\text{time average:} \quad \ln(\bar{G}) = \frac{1}{L} \int_0^L \ln[x(s)]\, ds$$

Geostrophic wind

The horizontal wind velocity, for which the horizontal component of the Coriolis acceleration exactly balances the horizontal pressure force.

Global radiation

See also: Solar radiation
The sum of the direct solar radiation and the diffuse sky radiation received on a unit horizontal surface.

Global scale

See also: Macro scale
A space scale which is of the order of magnitude of the earth's circumference (~10000 km).

Gradient transfer theory

See: Exchange coefficient hypothesis

Gradient wind

The horizontal wind velocity tangent to the isobars on a geopotential surface for which the centripital acceleration and the Coriolis acceleration balance the horizontal pressure force.

Gravitational fall

The downward settling of particles in the atmosphere due to the effects of gravity. The rate of descent of a particle depends on the balance between the aerodynamic drag and the gravitational acceleration (Stokes law). For particles with approximately the density of water and a diameter of less than 20 μm the fall velocity is too small compared with the vertical velocities in the atmosphere, so that these particles can remain aloft.

Green's function

A function associated with a given boundary value problem, which is a differential equation defined in a certain region and required to meet given boundary condition. The Green's function appears as the kernel in the integral representation of the solution of the equation.

Grid model

The numerical solution, usually by finite difference methods, of a problem in a Eulerian frame of reference at discrete points in space, which are called grid points. The solution at each grid point is calculated as a function of time.

Ground based inversion

A temperature inversion based at the ground surface. This type of inversion often forms during night time, when, due to radiative losses, the temperature of the surface drops, inducing the cooling of the air close to the surface.

Ground level concentration

Applied to the concentration, calculated or observed, in the neighbourhood of the ground surface.

Gustiness

See also: Intensity of turbulence
The fluctuation of wind speed over a specified time interval.

Half-life

The time required for a substance decaying at an exponential rate to be reduced to one-half its initial concentration or intensity.

Harmonic mean

The harmonic mean $\bar{H}$ is defined

- with respect to a sample of N discrete values x_i as

$$\frac{1}{\bar{H}} = \frac{1}{N} \sum_{i=1}^{N} \frac{1}{x_i}$$

- with respect to a continuously varying variable of space and/or time as

time average: $\frac{1}{\bar{H}} = \frac{1}{T} \int_0^T \frac{1}{x(t)}\, dt$

space average: $\frac{1}{\bar{H}} = \frac{1}{L} \int_0^L \frac{1}{x(s)}\, ds$

Hazardous pollutant

A pollutant for which no ambient air quality standard is applicable and that may cause serious environmental effects.

Heat flux

- In meteorology generally the transfer of heat between the surface and the atmosphere.
- In air pollution modeling the heat discharged by sources causing plume rise.

Heating season

The time of year when emissions due to domestic heating must be taken into account.

Heat island

An area, generally an urban or industrial complex, where the temperature is higher than that of its normally rural surroundings. The heat island effect may lead to a local circulation pattern in which air pollution can get trapped. The general effect of a heat island on the dispersion conditions is that the atmosphere is less stable over the urban or industrial complex than over the rural surroundings.

Heavy gas

A mixture of a gaseous air pollutant and air, where the density of this mixture is considerably greater than that of pure air. The dispersion of a heavy gas is influenced by gravity effects.

Homogeneity

A condition or process of which the properties are independent of a space coordinate.

Hydrostatic equilibrium

A condition which is realized when complete balance exists between vertical pressure forces and gravity forces.
The vertical equation of motion reduces for this condition to:

$$\frac{\partial p}{\partial z} = -\rho g,$$

where p is the pressure, z the vertical coordinate, ρ the density and g the acceleration of gravity.

Immission

Often used incorrectly for "ambient air quality"; however International Organization for Standardization defines the term "immission" as: "The transfer of contaminants from the atmosphere into an "acceptor" e. g. contaminants retained by the lungs. It does not mean ground level concentration."

Implementation plan

See: Strategy plan

Incompressible fluid

See also: Compressible fluid
A fluid for which the density can be considered only a function of the temperature. The speed of sound is infinite in such a fluid.

Independent variable

See also: Dependent variable, parameter

A quantity in an equation, which can be arbitrarily specified.

Indifferent

See: Neutral

Inert contaminant

- A gaseous or liquid contaminant that does not react with surrounding substances under ordinary circumstances.
- A contaminant that does not influence the fluid motions by which it is dispersed.

Inertial coordinate system

A coordinate system, in which the momentum of a body is conserved when no external forces are applied.

Inertial force

The resistance which a body experiences when its motion changes in a given coordinate system.

Inertial subrange

See also: Cascade process

The region in the energy spectrum of turbulence for which the wavelengths are small compared to the largest scales of turbulence where turbulent energy is generated, and large compared to the smalles scales, where turbulent energy is dissipated by viscous forces. The spectrum in this region is only determined by the wave number and the dissipation rate, which leads to a -5/3 power law for the spectrum.

Initial condition

The prescribing of all dependent variables in a differential equation at the initial time.

Insolation

The solar radiation at the earth's surface.

Instability

The property of a system whereby small disturbances introduced into it increase in magnitude.

Instability, numerical

A property of numerical algorithmes for differential equations, whereby the numerical solution will grow without bound, due to amplification of small errors in the computation, whereas the exact solution of the problem is bounded.

Installation

Part of a plant with a more or less independent operating and emission behaviour.

Instantaneous source

See: Source

Intensity of turbulence

A measure of the strength of the turbulence in a flow. Formally defined as the ratio of the standard deviation of a turbulent velocity component to the mean flow velocity.

Internal boundary layer

In boundary layer meteorology, an interface in the atmospheric boundary layer between flows with different turbulence characteristics. The interface usually starts at a discontinuous change of the surface characteristics. The height of the interface, which formally defines the internal boundary layer height, grows with the distance down wind of the discontinuity. On both sides of the interface different dispersion conditions are generally present.

Inversion

Generally used in meteorology with respect to an increase of temperature with height in contrast with the usual decrease of temperature with height in the troposphere. An inversion layer is distinguished by its large stability, which limits the turbulence and therefore the dispersion of pollutants.

Inversion, radiation

See also: Ground based inversion
The inversion which develops during the night over a land surface, caused by the strong cooling of the surface due to radiative losses. A favourable condition for the formation of a radiation inversion is a virtually cloudless sky during the night.

Inversion, subsidence

The inversion caused by the adiabatic warming of downward moving air. It is most common in connection with a high pressure area, in which average downward motions are present.

Irrotational

A flow field in which no vorticity is present throughout the whole field.

Isopleth

On a map a line of constant value of a certain property of quantity. For example, in air pollution modeling frequently used with respect to maps on which lines of constant concentration values are shown.

Isotropic

A condition or process of which the properties are independent of direction.

K-coefficients

See: Exchange coefficient

K-theory

See: Exchange coefficient hypothesis

Kinematic viscosity

See also: Viscosity
The kinematic viscosity ν is defined as $\nu = \mu/p$ where μ is the viscosity and p the density.

Kinetic energy

The energy which is possessed by a body as a consequence of its motion.

Knot

Unit of speed, usually applied in meteorology to the wind. One knot is defined as one nautical mile (1853 m) per hour.

Lagrangian frame of reference

See also: Eulerian frame of reference
A coordinate system in which the properties of a flow are described as a function of time and space where the coordinate system is attached to a fluid particle.

Laminar flow

A flow in which no turbulence is present. Diffusion in such a flow takes place only by molecular processes.

Land breeze

The breeze due to a local circulation near a shore line, which blows from the land towards the water. This local circulation is caused by a temperature difference between the water (warm) and the land surface (cold). The land breeze usually blows at night and alternates with the sea breeze.

Land-sea breeze circulation

See: Land breeze and sea breeze

Lapse rate

See also: Adiabatic lapse rate
Defined in meteorology as the change of temperature with height.

Large scale

See: Macro scale

Latent heat

The heat released or absorbed by respectively the condensation or evaporation of water.

Least square method

A technique of fitting a curve to a set of given points by minimizing the sum of the squares of the deviations of the given points from the curve.

Line source

See: Source

Local free convection

See also: Convection
The condition in the atmospheric boundary layer when forced convection should be assumed near the surface where mechanical turbulence is important and free convection at higher altitudes where thermal turbulence is important.

Lofting

The situation when air pollution is prevented from reaching the surface by a stable layer near ground level, while at emission height sufficient turbulence is still present. Lofting can occur during the transition from unstable to inversion conditions and is mostly observed near sunset.

Logarithmic wind profile

See: Wind profile, logarithmic

Log-normal distribution

A frequency distribution in which the logarithm of the variable in question is normally distributed.

Long range transport

The transport of air pollutants by the wind field over distances of the order of a 1000 km.

Long term average

The concentration value calculated or measured as an average over periods greater than one month (usually one year).

Looping

The vertical meandering of a plume during very unstable conditions caused by large turbulent eddies. The plume may reach the ground close to the source resulting in very high concentrations there.

Macro scale

In meteorology a length scale of the order of ten thousand kilometers. Applicable to large scale phenomena in the atmosphere e. g. tidal waves.

Markov process

A stochastic process in which the future state of the process is only dependent on the present state and not on any past states.

Mass flow rate (with respect to emission)

The pollutant mass transfer per unit of time from a source into the atmosphere.

Material balance

A comparison of all input and output streams of a given substance.

Mathematical model

A mathematical simulation of a real process, expressed as a set of equations.

Maximum credible accident

The most serious accident that can occur as a result of a feasible sequence of equipment failures. The design should be aimed at minimizing the risks resulting from such an accident.

Maximum mixing height

The maximum height of the mixing layer, usually attained over a land surface near sunset. In practice it is calculated from the temperature profile by determining the height of the intersection of this profile with the dry adiabat starting from the maximum ground level temperature.

Mean value

See also: Arithmetic mean, Geometric mean expectation, Harmonic mean
With respect to a set of data varying within a certain range, the mean value is representative for the centre value of the set.

Measuring

The determination by specialized equipment of the magnitude of a physical quantity (e. g. concentration).

Mechanical turbulence

Turbulence produced by shear stresses for instance related to a flow over a fixed surface. It is also applied to turbulence caused by separating flows around obstacles.

Meso scale

In meteorology a length scale of the order of a hundred kilometers. Applicable to phenomena such as land-sea breeze, mountain-valley wind etc.

Meteorological conditions

The complex of meteorological parameters which are relevant when studying a phenomenon in the atmosphere.

Micro scale

In meteorology a length scale of the order of the predominant scale of turbulence in the atmospheric boundary layer. Values of this scale vary between a few meters and several kilometers.

Mixing depth

The thickness of the atmospheric layer near the surface in which air pollutants are dispersed by turbulence. At the top of the mixing layer a barrier to the dispersion is often formed by a temperature inversion.

Mixing height

See: Mixing depth

Mixing length

The characteristic length over which a property is transported by the predominant turbulent eddies. This length enters into the exchange coefficient of the property in a turbulent flow.

Modeling

The simulation of a real process by a set of mathematical equations or by a physical experiment in order to study and/or quantify this process.

Model calibration

Adjustment of the results of an air pollution simulation model to fit measured concentration data. This is usually done by specifying some free constants in the model.

Moisture

The water vapor content (liquid and gaseous) of the atmosphere.

Molecular diffusion

See also: Diffusion
The diffusion of a property within a fluid by molecular processes. In a turbulent flow molecular diffusion is often negligeable compared to diffusion by turbulence.

Moment of a distribution

For a variable x defined on the interval $x_1 \leq x \leq x_2$ with the associated frequency function f(x) the k-th moment μ_k about the point a is defined as

$$\mu_k = \int_{x_1}^{x_2} (x-a)^k \, f(x) \, dx$$

The first moment for a = 0 is the expectation and the second moment for a equal to the mean value is the variance.

Momentum

The quantity of motion measured by the product of the mass and the velocity of a body.

Monin-Obukhov length

See also: Dimension analysis

A turbulence parameter with the dimension of a length in the atmospheric surface layer. This parameter provides a measure of stability, being infinite for neutral conditions, negative for unstable and positive for stable conditions. It is given by the equation

$$\frac{1}{L} = \frac{g}{T_o} \frac{H}{\rho c_p u_*^3}$$

where H is the sensible heat flux, g the acceleration of gravity, T_o the absolute temperature in the surface layer, ρ the density, c_p the specific heat at constant pressure and u_* the friction velocity.

Many turbulence parameters in the atmospheric surface layer can be expressed in the form of similarity relations depending only on the ratio of height to the Monin-Obukhov length.

Monitoring

Process of making continuous, periodical or random quantitative observations of emission or ambient air quality.

Monitoring may be:

- continuous: monitoring without interruption throughout a given period
- periodical: monitoring with fixed time intervals between consecutive observations
- random: monitoring with time intervals determined on a random basis between consecutive observations.

Monte Carlo method

A procedure which by using statistical sampling techniques leads to a probabilistic approximation to the solution of a mathematical or physical problem.

Mountain-valley wind

A diurnal variation of the wind, in a mountain-valley blowing uphill by day and downhill by night forming a mesoscale circulation system.

Multiple stacks

Closely grouped point sources where the plumes may mutually influence each other e. g. with respect to plume rise.

Natural emission

Emission caused by natural processes, e. g. by volcanoes, forest fires, wind-blown sand, swamps, sea-spray, etc...

Neutral

The property of a system whereby small disturbances introduced into it, neither grow nor die out.

Neutral atmosphere

See also: Adiabatic process
The atmospheric condition for which the vertical temperature profile is equal to the adiabatic lapse rate over the whole boundary layer. Vertical air motions are neither enhanced nor suppressed. The turbulence intensity is moderate.

Non-degradation principle

A principle of avoiding deterioration of the present state of ambient air quality (also called "stand-still principle").

Non deterministic model

A model which is based on empirical relationships between air quality data and other parameters which are given for a certain period of time. It is then used to calculate the air quality in another period. In this model no direct relation is established between air quality and emissions.

Normal distribution

The continuous frequency function f(x) for the variable x for $-\infty < x < \infty$ represented by the equation

$$f(x) \frac{1}{\sigma\sqrt{2\pi}} e^{-0.5 \left(\frac{x-m}{\sigma}\right)^2}$$

where m is the mean and σ the standard deviation of the distribution.

Numerical diffusion

See: Pseudo diffusion

Numerical modeling

The solution by numerical techniques of a set of equations resulting from a mathematical model.

Obukhov length

See: Monin-Obukhov length

Orographic

The nature of a terrain with respect to differences in its elevation.

Orthogonal

With respect to the functions $f_i(x)$ and $f_j(x)$ defined on the interval $x_1 < x < x_2$ orthogonality is defined as

$$\int_{x_1}^{x_2} f_i(x) f_j(x)\, dx = 0 \text{ for all } i \neq j$$

The function are called orthonormal when

$$\int_{x_1}^{x_2} f_i^2(x)\, dx = 1$$

Parabolic equation

See also: Diffusion equation

A type of partial differential equation by which the process of diffusion is normally described. A typical example is the heat equation of which the one-dimensional form reads:

$$\frac{T}{t} = k \frac{\partial^2 T}{\partial x^2}$$

describing the diffusion of temperature in a one-dimensional medium (e. g. a bar).

Parameter

See also: Dependent variable, Independent variable

A quantity in an equation which must be specified beside the independent variables to obtain the solution for the dependent variables.

Partial differential equation

See: Differential equation

Particulate matter

Small solid or liquid particles suspended in or falling through the atmosphere. Sometimes expressed by the term particulates.

Percentile

A value of the set of partition points which divide a distribution function into one hundred equal parts.

Persistence

The continuation of the same situation during a specified period of time. Often used in air pollution meteorology with respect to wind direction. In that case it is also called steadiness or constancy.

pH

Formally defined as minus the common logarithme of the hydrogen ion concentration of a solution. It is a measure to indicate whether a solution is acid (pH < 7) or alkaline (pH > 7).

Photochemical reaction

A chemical reaction between different air pollutants involving absorption or emission of radiation.

Photochemical smog

A mixture of secondary air pollutants including ozone, organic nitrates etc., which are produced from primary pollutants such as nitrogen oxides, hydrocarbons etc. by photochemical reactions.

Physical model

The simulation of a real process by a physical experiment, which models the important features of the original process that are the object of study. For instance, the simulation of a dispersion problem in a windtunnel.

Physical source height

See: Effective source height.

Planetary boundary layer

The layer in the atmosphere near the earth's surface, where the influence of the surface is present primarily through frictional forces. It is usually subdivided into two sections: the surface layer and the Ekman layer.

Plume

The shape of the concentration distribution of the emissions from a point source when transported by the mean wind and dispersed by turbulence.

Plume path

The curve along which the plume moves in the atmosphere. The form and direction of this curve is determined by the buoyancy of the plume, its exit speed, the wind profile, the stability of the atmosphere and the turbulence in the atmosphere.

Plume rise

The upward motion of a plume after its emission from the source due to its exit velocity and/or its buoyancy. This buoyancy is caused by the higher temperature of the plume with respect to its surroundings.

Point source

See: Source

Pollution rose

A diagram in which for each wind direction is indicated the average concentration for the time period that this wind direction occurs.

Potential temperature

See also: Adiabatic process

The temperature θ which a particle of dry air has when it is transported isentropically to a standard pressure (usually 1000 mb). It is given by the equation

$$\theta = T\left(\frac{1000}{p}\right)^{R/c_p}$$

where T is the temperature of the parcel, p its pressure in mb, R the gas constant for dry air and c_p the specific heat at constant pressure. The potential temperature is directly related to the entropy. In a neutral atmosphere the potential temperature is constant, it increases with height in a stable atmosphere and decreases in an unstable atmosphere.

Product standard

Legally binding specification for the composition of fuels, raw materials and products. The term "product standard" is not used in all countries.

ppb

A concentration defined as 10^{-3} times the concentration in ppm.

ppm

A measure of concentration usually indicating the number of volume parts of a substance per 10^6 volume parts of air. Its relation to the concentration expressed in $\mu g/m^3$ is given at a normal pressure and temperature by

$$ppm = \frac{c}{M} * 0.022$$

where c is the concentration in $\mu g/m^3$ and M the molecular weight of the substance.

Precipitation

In meteorology the solid or liquid water particles that fall from the atmosphere and reach the ground.

Precursors

Primary air pollutants with respect to photochemical air pollution.

Primary air pollutant

Pollutant remaining in the same form as it was when emitted from the source.

Pseudo diffusion

The extra diffusion which in the numerical solution of the diffusion equation results from the truncation error related to the finite differencing of the advection terms. Its magnitude is dependent on the particular finite difference scheme that is used. It may sometimes completely mask the influence of the other diffusion terms in the equation.

Pseudo spectral method

A numerical solution method related to the Galerkin method. The solution is represented by a truncated Fourier series. In the pseudo spectral method the Fourier series are only used to evaluate the space derivatives in the problem, so that these derivatives are calculated in Fourier space, while the time derivatives and the local products are evaluated in real space on grid points.

Puff model

See also: Gaussian puff model
A mathematical model which describes the transport and dispersion of pollutants in the atmosphere from a source by releasing a quantity of pollutant at each time step (in the case of an instantaneous source one release is sufficient). This quantity of material is transported by the wind field and dispersed by turbulent diffusion.

Radiation

The process of energy transport by electromagnetic waves(e. g. sun light) or by fast moving atomic particles (e. g. radioactive alpha and beta radiation).

Radiational cooling

See also: Inversion, Radiation
In meteorology usually employed with respect to the cooling of the earth's surface, particularly during the night caused by radiational heat losses by the surface.

Radiosonde

An instrument which rises through the atmosphere by mean of a balloon and which measures and simultaneously transmits meteorological data, usually pressure, temperature and humidity.

Rainout

The scavenging of air pollutants in clouds by liquid or solid water particles.

Random walk

The step-wise path along which a particle moves, where each step is determined by chance with regard to direction and/or with regard to magnitude.

Real time mode

The use of an air quality simulation model for immediate application taking into account current input data.

Receptor point

The geographical point where an air pollutant concentration is measured or is calculated by means of an air pollution dispersion model.

Reference method

See: Standard method.

Reflection

In air pollution modeling used when due to the presence of a physical barrier to the diffusion the pollutant is assumed to be reflected by this boundary. Mathematically this is performed by assuming an image source symmetrically with respect to the boundary.

Regional scale

See also: Urban scale
In air pollution modeling a length scale of the order of a hundred kilometers. Usually applied to an area encompassing urban and/or industrial areas.

Regression

A relation giving the conditional expected value of a random variable y for given values of the independent variable x in the form $y = f(x)$. When $f(x)$ is a linear function of x the term linear regression is used. The parameters in the function $f(x)$ are determined by the method of least squares.

Relative diffusion

The dispersion of a cluster of particles considered with respect to each other.

Relative humidity

A measure of the water vapor content of the atmosphere calculated as the ratio of the vapor pressure in the atmosphere to the saturation vapor pressure at the existing temperature.

Remote sensing

Quantitative or qualitative determination of air pollutants or of meteorological parameters by means of instruments not in physical contact with the sample being examined.

Removal processes

See also: Scavenging
All the physical processes which remove air pollutants from the atmosphere causing a decrease of the concentration of the air pollutants.

Residence time

The characteristic time during which a substance remains in the atmosphere after its emission, taking into account all the possible sinks of this substance.

Reynolds analogy

The assumption that the turbulent diffusivities for heat and momentum are equal.

Reynolds number

The dimensionless number expressing the ratio of the inertial forces to the viscous forces for a given flow. It is given by the equation

$$Re = \frac{UL}{\nu}$$

where U is a characteristic flow velocity, L a characteristic flow length scale and ν the kinematic viscosity.

Reynolds stress

The apparent stress on the mean flow caused by turbulent velocity fluctuations which transport momentum. It is calculated as the correlation of these turbulent velocity fluctuations.

Richardson number

A dimensionless number expressing the ratio of the production of turbulent energy by buoyancy forces to the production of turbulent energy by shear forces. It can be defined in two forms:
- the flux Richardson number:

$$Ri_f = \frac{g}{T_o} \frac{H}{c_p \tau \, \partial u/\partial z}$$

where g is the acceleration of gravity, H the sensible heat flux, T_o the absolute boundary layer temperature, c_p the specific heat at constant pressure, τ the shear stress and $\partial u/\partial z$ the vertical velocity gradient.

- the gradient Richardson number:

$$Ri = \frac{g}{T_o} \frac{\partial\theta/\partial z}{(\frac{\partial u}{\partial z})^2}$$

where $\frac{\partial\theta}{\partial z}$ is the vertical potential temperature gradient.

Roll back model

A simple empirical model which directly relates air quality to emissions. In this model the contribution to the background concentration by the local sources is considered directly proportional to the total emission. The constant of proportionality is assumed to be independent of the emission changes.

Rossby number

The dimensionless number expressing the ratio of the inertial force to the Coriolis force for a given flow. It is given by the equation

$$Ro = \frac{U}{fL}$$

where U is the characteristic flow velocity, L a characteristic length scale of the flow and f the Coriolis parameters.

Roughness length

A characteristic length which is a measure of the roughness of a surface. It enters as a parameter in the logarithmic wind velocity profile.

Sampling

In statistics the selection of a finite subset of a population. In air pollution usually applied to the measuring of ambient air quality or of emissions.

Sampling duration

The total time period during which samples of a function are collected.

Sampling time

See also: Averaging time
The characteristic time over which a sample usually of a continuously varying function of time is obtained as an average. When measuring air pollution the minimal sampling time is determined by the intrinsic averaging time of the sampling apparatus.

Scalar

See also: Tensor, Vector
A physical quantity which possesses only a magnitude and which therefore can be described by only one numerical value in an arbitrary point of space. An example of a scalar is the concentration.

Scale

A characteristic length or time period in a problem.

Scavenging

The processes in the atmosphere causing the decrease of the concentration of an air pollutant by removal of this pollutant from the atmosphere. Usually applied to the physical process of the capture of air pollutants by falling or floating water droplets (washout, rainout). Chemical scavenging processes are usually described by decay or photochemical reactions. Scavenging processes in relation to adsorption at a surface are described by deposition.

Sea breeze

See also: Land breeze
The breeze due to a local circulation near a shoreline, which blows from the water to the land surface. This local circulation is caused by a temperature difference between the water (cold) and the land surface (warm). The sea breeze usually blows during the day time and alternates with the land breeze.

Sea-land breeze circulation

See: Sea breeze, Land breeze

Secondary pollutant

Pollutant produced by chemical and/or physical reactions which take place in the atmosphere. The term "secondary pollutant" is not used in all countries.

Sedimentation

The settling out of particles in the atmosphere due to their gravitational fall.

Sensible heat

The heat content of the air, equal to the thermodynamic enthalpy which is given by the equation

$$h = c_p T$$

where h is the enthalpy per unit mass, c_p the specific heat at constant pressure assumed to be constant and T the absolute temperature. It is used in contrast to the term latent heat.

Sensitivity analysis

In air pollution modeling the systematic examination of changes in the output variables of a mathematical model due to small variations in the input variables or model parameters.

Separation region

In a flow field a region distinct from the main flow in which the fluid recirculates behind an obstacle.

Series

In mathematics the sum of a finite or infinite sequence of terms or functions.

Shear

The variation of a vector quantity in magnitude and direction along a given line in space.

Shearing stress

The stress in a fluid tangential to a given surface. This stress is connected to the shear in the fluid.

Short term air quality control

The control of air quality over time periods of the order of one hour to one day.

Short term average

The calculation of concentration averaged over periods from one hour to about one day.

Significance

An estimate of whether an observed statistical result is really present in a set of data or possibly due to sampling error or random fluctuations in the data.

Similarity relation

See: Dimensional analysis

Sink

All the processes resulting in a removal of air pollutants from the atmosphere.

Simulation

See: Modeling

Smog

See also: Chemical smog
Formerly primarily applied to a mixture of smoke and fog in some urbanised areas. Nowadays also applied to air pollution problems which involve a reduction of the visibility.

Smoke

Particulate matter in the atmosphere resulting from the emissions of combustion processes in such concentrations that it is visible.

Snowout

The capture of gaseous or particulate air pollution by precipitation in the form of snow.

Solar radiation

The total electromagnetic radiation emitted by the sun. It can be subdivided into direct solar radiation (the energy reaching the surface directly in the solar beam) and diffuse sky radiation (the energy reaching the surface after having been scattered from the direct solar beam).

Source

The place where pollutants are emitted into the atmosphere. Sources may be point, area or line sources:
- point source: a source whose transition area of emissions into the environment is treated as a point
- area source: source(s) whose emissions can be treated as if they were homogeneously distributed over a certain area.
- line source: source(s) whose emissions are relatively homogeneously distributed over an area with a width small enough compared to its length to be treated as a line.

Often the term "source" is used for a whole plant or an installation.

In air pollution modeling, in addition the therms "continuous source" instantaneous source" are used:

- continuous source: source which emits pollution continuously over a time period much larger than the travel time to a point where the concentration is considered. Usually it is assumed that during this time period the emission is constant.
- instantaneous source: source which emits pollution over a time period much shorter than the travel time of the emission to a point where its concentration is considered.

Source configuration

The geographical position and distribution of the area, line and point sources in a region.

Source height

The height of a source above the surrounding ground surface.

Source test

Measurement of emission, to determine concentrations and/or mass flow rates.

Spectral model

The solution of a set of equations describing a given problem by an eigenfunction expansion.

Spectrum

See also: Fourier analysis

- A function which expresses the contribution to the variance of a time series of data by each wave length or frequency that can be resolved from the data. In turbulence often used with respect to the turbulent energy spectrum.
- The set of eigenvalues of an operator. In this case the spectrum can be continuous or discrete.

Stability

See also: Instability
The property of a system whereby small disturbances applied to it decrease in magnitude.

Stability, numerical

See also: Instability, numerical
The property that a numerical solution scheme is stable with respect to small errors introduced during the computation.

Stability classes

See: Diffusion categories

Stable

Used with respect to the atmospheric boundary layer, when the vertical temperature gradient is greater than the adiabatic lapse rate. Vertical air motions are suppressed. The turbulence intensity is low resulting in poor dispersion conditions.

Stack

A source of air pollution in the form of a vertical pipe.

Stack height

See: Effective source height, physical source height.

Stagnation

A meteorological condition which is characterized by the occurrence of a stable air mass with low wind speeds that persists over several days. High concentrations of air pollution may occur caused by the accumulation of pollutants in this air mass.

Standard deviation

The positive square root of the variance. It is a measure of the scatter or spread in a data set.

Standard method

A method for measuring (including sampling and analyzing) certain parameters, established by law or guidelines.

Stand-still principle

See: Non-degradation principle.

Stationary

A condition or process of which the properties are independent of time.

Statistical model

See also: Non deterministic model
A model which is based on the statistical analysis of a time series of data which may consist of air quality data, meteorological data etc. (e. g. multiple regression models).

Steady state model

A model which is based on the assumption of stationary conditions during the period that the model is applied (e. g. Gaussian plume model).

Stochastic model

A model in which dispersion is described statistically by the random motions of a number of clusters within a turbulence field which is also represented by random moving clusters. The clusters interact through collision and coagulation processes and they are also influenced by decay into smaller clusters.

Stokes law

The law which describes the terminal fall velocity of a small particle in a fluid, when an equilibrium exists between gravity and viscous forces. The fall velocity for a spherical particle is given by the equation

$$v_F = \frac{2}{9} \frac{a^2 g}{\nu} \left(\frac{p}{p_o} - 1\right)$$

where g is the acceleration of gravity, a the diameter of the particle, ν the kinematic viscosity, p the density of the particle and p_o the density of the medium through which the particle is falling.

Strategy plan

A plan containing coordinated legislative, administrative and technical measures necessary to achieve a desired, or to maintain an existing, level of ambient air quality.

Stratified fluid

A fluid in which a density variation along the axis of gravity is present influencing the fluid motions.

Stream function

The function in two dimensions, which is constant along each streamline in a fluid.

Stream line

The line tangent to the instantaneous velocity vector at each point in a fluid.

Street canyon model

The model which describes the dispersion of air pollutants by the local air circulation in a street between two rows of high buildings. Primarily of importance where the dispersion of traffic emissions is concerned.

Stress

With respect to fluid mechanics defined as the force per unit area on a given surface in a fluid.

Subsidence

The mean descending motion of the air in the atmosphere usually in connection with a high pressure area.

Superadiabatic

The condition where the temperature lapse rate is smaller than the dry adiabatic lapse rate resulting in unstable conditions.

Surface energy balance

The balance between the incoming and outgoing energy at the earth's surface. The energy consists of radiation (short wave and long wave), turbulent fluxes (sensible heat and latent heat flux) and other fluxes (e. g. ground heat flux).

Surface friction

The drag or shear stress of the earth's surface on the air motion above the surface.

Surface layer

The lowest part of the atmospheric boundary layer adjacent to the surface. Usually defined as the layer in which the shear stress can be considered to be independent of height.

Surface weather observation

The observation of different meteorological parameters at the surface, such as temperature, wind speed and direction. These observations are usually routinely done at a large number of stations at fixed hours each day.

Synergistic effect

The cooperative action of different pollutants such that the total effect is greater than the sum of the effects taken independently.

Synoptic scale

In meteorology a length scale of the order of one thousand kilometers. Applicable to phenomena such as synoptic high or low pressure areas.

Taylor hypothesis

The hypothesis by which turbulence properties can be defined as a function of space from measurements of this property as a function of time. The assumption is made that the turbulent fluctuations are advected unchanged across the instrument with the mean wind speed.

Temperature

Formally defined as the integrating factor in the equation expressing the first law of thermodynamics. In practice a measure for the hotness or coldness of an object with respect to a specified temperature scale.

Temperature gradient

See also: Lapse rate
The change of temperature along a given line in space.

Temperature profile

The description of the temperature as a function of height.

Tensor

A physical quantity which obeys certain laws of transformation in a given space. Scalars can be regarded as tensors of the zeroth order and vectors as tensors of the first order. An example of a tensor of the second order is the stress tensor.

Terminal velocity

See also: Stokes law

The fall velocity of a small particle in a fluid, when the drag and gravity forces are in equilibrium.

Thermal turbulence

Turbulence produced by buoyancy forces. In the atmospheric boundary layer usually applied to the turbulence caused by rising air motions due to the heating of air at the earth's surface.

Topography

The features, natural and man-made, of the earth's surface.

Tracer

A detectable and inert substance released in the atmosphere to study processes such as diffusion, advection, etc. Its concentration change due to loss processes must be minimal.

Trajectory

The path of a particle in a fluid when it assumes at each time the velocity of the surrounding fluid. In the atmosphere this conception is often used when only the horizontal motions of a particle are taken into account.

Trajectory model

A model which describes the transport and diffusion of a puff of air pollution along a usually horizontal trajectory in the atmosphere. Removal and/or transformation processes can be taken into account.

Transformation process

See also: Secondary pollutant

The chemical and physical processes in which a pollutant reacts with other pollutants or normal atmospheric constituents, forming other air pollution components.

Transport

See: Advection

Trapping

The condition when the diffusion of air pollution is confined to a small mixing layer capped by a strong inversion.

Trend

The general drift in an ordered time series of data.

Turbulence

A fluid motion at high Reynolds numbers characterized by irregular or random flow fluctuations and high fluctuating vorticity resulting in a large dissipation of kinetic energy and a rapid mixing of flow properties and passive contaminants throughout the turbulent flow regime.

Turbulence, homogeneous

Turbulence for which the statistical properties are independent of the location in the flow field.

Turbulence, isotropic

Turbulence for which the statistical properties are independent of the orientation of the coordinate axes.

Turbulent diffusion

Diffusion of a property caused by turbulent motions in a fluid as opposed to molecular diffusion.

Uncontrolled emission factor

See: Emission factor.

Validation

The testing of a model by comparing its results with experimentally obtained data.

Variance

The second moment of a distribution about its mean giving a measure for the width of the distribution.

Variable wind

Wind for which no specific direction can be defined. The wind speed is usually small.

Vector

A physical quantity which possesses a magnitude and a direction in each point of space. An example of a vector is the velocity.

Veering wind

Clock-wise rotation of the wind direction.

Ventilation factor

A parameter used in connection with the box model. It is defined as the product of the horizontal wind velocity and the surface of the box perpendicular to the wind direction.

Verification

See: Validation

Vertical wind

The component of the wind velocity along the local vertical direction. This component is usually small compared to the horizontal wind velocity.

Virtual point source

See also: Area source
A description of the emissions from an area source by assuming that this source can be represented by a point source. This approximation will improve with increasing distance from the source.

Virtual temperature

An effective air temperature which incorporates into this temperature the effects of humidity on the density and pressure. It is formally defined as the temperature of dry air having the same density and pressure as the moist air.

Viscosity

A molecular property of a fluid resulting in shear stress opposing a shearing deformation of the fluid. In most common fluids the shearing stress is directly proportional to the shearing deformation. The constant of proportionality is called the viscosity μ with the dimensions kg/(ms).

Visibility

The greatest distance in a given direction at which it is just possible to see and identify a prominent dark object in the day time or a light source in the night time.

Von Karman constant

See also: Wind profile, logarithmic
The empirical constant which originates from the logarithmic wind profile.

Vorticity

A measure of the rotation of a fluid element. It indicates twice the angular velocity at each point in a fluid.

Washout

The capture of gaseous or particulate air pollutants by precipitation.

Wake

In a flow field a region behind an obstacle in which the fluid flow is disturbed due to the presence of this obstacle.

Wave length

For a spacially oscillatory phenomenon it is the least distance between points moving in the same phase.

Wave number

In the space Fourier analysis of a function the wave number is the reciprocal of the wave length.

Wet deposition

The material deposited on the surface due to the combined effect of washout, rainout and snowout.

Wind

The motion of the air relative to the earth's surface. Usually applied only to the horizontal component of this motion.

Wind direction

The direction from which the wind averaged over a certain period of time is blowing.

Wind field

The description of the three dimensional wind speed and wind direction distribution in a certain region for each time.

Wind fluctuation types

A definition of diffusion categories by the width and the appearance of the trace drawn by a continuously recording wind vane. In this way a direct connection of the diffusion categories with the turbulent wind direction fluctuations is obtained. A well-known example are the Brookhaven diffusion categories.

Wind profile

The description of the wind speed and direction as a function of height.

Wind profile, logarithmic

The variation of the wind speed (u) with height (z) following a logarithmic equation of the following form

$$u = \frac{u_*}{k} \ln \left(\frac{z-d}{z_o}\right)$$

where u_* is the friction velocity, k the von Karman constant, d the zero-plane displacement and z_o the roughness length. The logarithmic velocity profile occurs in the turbulent flow near the earth's surface in neutral conditions.

Wind profile, power law

The empirical equation describing the variation of the wind speed (u) with height (z) in the following form

$$u = u_1 \, (z/z_1)^p$$

where z_1 is the reference height with the reference wind speed u_1 and p is the exponent. In general the exponent p is a function of stability, roughness and also height.

Wind rose

A diagram showing the distribution of wind directions at a certain location for a given period of time.

Wind direction sector

See also: Climatological frequency distribution
A sector consisting of several adjacent wind directions. Applied for example in the Gaussian plume model for long term averages to describe the influence of the wind direction on the dispersion pattern during the calculation period.

Wind speed class

See also: Climatological frequency distribution
The combination of several wind speeds in one class. Applied for example in the Gaussian plume model for long term averages to describe the influence of the wind speed on the dispersion during the calculation period.

Wind vane

An instrument used to measure the wind direction.

Worst case

The combination of meteorological conditions, topography and source characteristics for which locally the highest air pollutant concentrations for a given averaging time occur.

Zero-plane displacement

See also: Wind profile, logarithmic

A parameter in the logarithmic wind profile used to indicate the effective height of the surface. This parameter extends the applicability of the logarithmic profile to very rough surroundings e. g. a forest.

ANNEX I

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ANNEX II

NATO/CCMS Documents on the First Air Pollution Pilot Study (available at: NATO/Committee on the Challenges of Modern Society, NATO Headquarters, Brussels, Belgium)

AIR POLLUTION (No. 5)

Proceedings of the 2nd Meeting of the Expert Panel on Air Pollution Modeling, (26 - 27 July 1971, Paris, France) Out of stock

AIR POLLUTION (No. 6)

Guidelines to Assessment of Air Quality (Revised)

APPENDIX A	Assessment of Air Quality in Ankara (February 1973)
APPENDIX B	Assessment of Air Quality in St. Louis (February 1973)
APPENDIX C	Assessment of Air Quality in Frankfurt (June 1974)
APPENDIX D	Assessment of Air Quality in Oslo (February 1973)
APPENDIX E	Assessment of Air Quality in South Holland Region (December 1973)

AIR POLLUTION (No. 7)

Quality Criteria for Sulphur Oxides (November 1971) Out of stock

AIR POLLUTION (No. 8)

Air Quality Criteria for Particulate Matter (November 1971) Out of stock

AIR POLLUTION (No. 10)

Air Quality Criteria for Carbon Monoxide (June 1972)

AIR POLLUTION (No. 12)

Control Techniques for Sulphur Oxide Air Pollutants (October 1973)

AIR POLLUTION (No. 13)

Control Techniques for Particulate Air Pollutants (October 1973)

AIR POLLUTION (No. 14)

Proceedings of the 3rd Meeting of the Expert Panel on Air Pollution Modeling
(2 - 3 October, 1972, Paris)

AIR POLLUTION (No. 15)

Air Quality Criteria for Nitrogen Oxides (June 1973)

AIR POLLUTION (No. 18)

Control Techniques for Carbon Monoxide Emissions from Stationary Sources (October 1973)

AIR POLLUTION (No. 19)

Control Techniques for Hydrocarbon and Organic Solvent Emissions from Stationary Sources (October 1973)

AIR POLLUTION (No. 20)

Control Techniques for Nitrogen Oxide Emissions from Stationary Sources (October 1973)

AIR POLLUTION (No. 29)

Air Quality Criteria for Photochemical Oxidants and Related Hydrocarbons (February 1974)

AIR POLLUTION (No. 30)

Proceedings of the 4th Meeting of the Expert Panel on Air Pollution Modeling, (28 - 30 May 1973, Oberursel, Germany)

AIR POLLUTION (No. 33)

Final Report (May 1974)

AIR POLLUTION (No. 35)

Annex III

NATO/CCMS Documents on the Pilot Study on Air Pollution Assessment Methodology and Modeling
(available at: NATO/Committee on the Challenges of Modern Society, NATO Headquaters, Brussels, Belgium)

Air Pollution (No. 42)

Proceedings of the 6th International Technical Meeting on Air Pollution Modeling and its Application
(24 - 26 September 1976, Frankfurt/Main, Germany)

Air Pollution (No. 51)

Proceedings of the 7th International Technical Meeting on Air Pollution Modeling and its Application
(7 - 10 September 1976, Airlie House, USA)

Air Pollution (No. 70)

Bibliography on Grey Literature on Air Quality Modeling, Part I (Applied Models)

Air Pollution (No. 71)

Air Quality Management Systems

Air Pollution (No. 88)

Bibliography on Grey Literature on Air Quality Modeling, Part II (New Modeling Techniques)

Air Pollution (No. 89)

Glossary of Terms Generally Used in Air Pollution Assessment Methodology and Modeling

Air Pollution (No.)

Proceeding of the 8th International Technical Meeting on Air Pollution Modeling and its Application
(20 - 23 September 1977, Louvain-la-Neuve, Belgium)

Air Pollution (No. 100)

Air Pollution Emission Projecting

Air Pollution (No. 99)

Introduction to Air Quality Modeling